Glass and Ceramics Vol. 61, Nos. 1 – 2, 2004

UDC 666.65.032.6

CAUSES OF DEFECTS IN TECHNICAL CERAMICS OCCURRING IN MOLDING ON PRESSES

M. I. Timokhova[1]

Translated from Steklo i Keramika, No. 2, pp. 19 – 22, February, 2004.

The causes of certain types of defects in static bending of ceramics on automated presses are analyzed. Recommendations are issued for elimination of defects in order to improve the quality of products in serial production.

Static molding is one of the most common methods in the ceramic industry [1].

It is known that the properties of ceramic articles depend on structure, density, and homogeneity of the molded intermediate product, which, in turn, depend on technological properties of molding powders. The most significant properties of powders influencing the mold design and sizes and the quality of molded products include the content of technological binder, bulk weight, friability, granulometric composition, compression coefficient, natural slope angle, moldability of powder, etc. [2].

In molding articles on automated press-machines, bulk weight, friability, and granulometric composition acquire special significance.

Powders with higher bulk weight are more suitable for molding. Powder with lower bulk weight have poor fluidity and lower friability, which creates difficulties in charging powder into a mold and in molding, since they require a matrix with a larger working part and a substantial displacement of the punch, which increases friction between the powder and the mold, thus developing stresses in molded articles.

To increase bulk weight, ceramic technology uses granulation of molding powder, which also increases its friability and abrasion resistance. The properties of fired products in this case improve as well: the volume mass and mechanical strength increase and the fire shrinkage decreases. However, briquetting pressure should be carefully selected, i.e., it should not exceed the article molding pressure. Excessive density and rigidity of granules impede the formation of a continuous homogenous molded product. A “granular” structure has a negative effect on the quality of the end product, especially decreasing its electrical strength.

Experimental studies and long-term practical experience of using molding powders in industrial production established that powder briquetting pressure should be 50 – 70% of unit molding pressure [3].

Friability of molding powder is an important parameter of moldable materials. High friability is needed for fast continuous supply of required portions of powder into the mold, which is especially significant for automatic molding and for filling molds designed for products of complex configurations and thin-walled articles.

It should be noted that powders produced in spray dryers have high friability, but their moldable properties are to some extent inferior to those of powders produced by briquetting [3].

The granulometric composition of molding powder is very important for molding technology. When selecting this composition, one is guided by the principle of achieving a maximum possible density of particle packing. The granulometric composition is responsible for molding pressure required to reach a preset density, sintering shrinkage, and physicomechanical properties of finished articles. Molding powder should have good friability and molded articles should have steady sizes.

The densest packing is reached in the case of powder compositions containing two or three fractions. Theoretically, the optimum packing for a two-fraction powder mixture can be obtained with a fine-fraction content of 28.3% and a coarse-fraction content of 71.7%. Industrial production normally uses two-fraction molding powders of the following approximate composition: 60 – 70% coarse-fraction grains and 40 – 30% fine-fraction grains.

Special attention in preparing molding powder should be paid to controlling the quantitative content of the dustlike fraction, which should not exceed 10% for molding on hydraulic presses. It is best if the content of this fraction is 5 – 6%, and in making miniature ceramics on automatic presses, its content should not exceed 2 – 4%. This restriction on the content of the dustlike fraction is due to the fact

[1] Reméko Company, Moscow, Russia.

TABLE 1

Types of defects	Possible causes	Measures for eliminating defect
Overall sizes of product are too large or too small	Molding pressure was not maintained Deviations in mold sizes Unstable molding powder	Adjust molding pressure, measure the mold Stabilize molding powder
Product sizes are not maintained across its thickness	The height of the mold charge chamber is not adjusted Unstable molding powder	Adjust the height of the charge chamber Strictly control molding powder parameters
Disruptions on face surface of article	Poorly polished punch	Polish the punch
Disruptions along the recess perimeter in article produced by differential molding	Disturbance of parallelism in working surfaces of the press and the mold Discoordination in the length and thickness of the floating punch spring Insufficient quality of the floating punch Skewing of the floating rod	Position the mold in parallel Check the length and thickness of the spring to comply with the blueprint Install the punch Remove the rod and purify it from sticking powder Replace it with a new rod if unsuitable
Disruptions in the upper edge of molded article	Skewing of mold parts	Install the punch strictly perpendicular to the molding plane Check coaxial, perpendicular, and parallel alignment of the press table, upper traverse and the pusher
Tearing out the upper edge of bushing-shaped article from the side of the molding rod	Absence of conicity Insufficient cone The cone does not correspond to the total article height	Apply a cone to the molding rod Increase the conicity of molding punches (the cone should reach the whole height of article in molding)
Disruptions in the upper edge of molded article from matrix side	Skewing of the matrix	Check the flatness of the matrix ends and its settling site
Flashes on articles on two or four sides	The punch is shifted to one side The punch is worn along the perimeter	Install the punch correctly Perform individual selection of a punch based on the matrix Replace the punch
Flash along the recess perimeter	Wear of the molding rod	Replace the rod
Insufficient compression of certain sites (visible porosity)	Nonuniform charging of powder into the mold	Provide for uniform loading of molding powder and its flush removal
Low mechanical strength after molding	Insufficient molding pressure The lower punch is not fully lowered during charging Insufficient content of plastifier in molding powder	Increase molding pressure (or check the compliance of the manometer readings to true pressure) Adjust the lower punch, clear it from sticking-on mixture Increase plastifier content
Insufficient strength of molded corners, chips	Intense wear of punch, collapse in punch corners	Replace the mold Polish the punch
A ring-shaped crack on bottom part of the product	Matrix worn out	Polish the matrix
A light-color spot on articles in molding (on the reverse side of the recess)	Decreased density in the recess	In molding by means of the floating punch, decrease floating of the part shaping the recess
A dark spot on articles ion molding (on the reverse side of the recess)	Excessive density in the recess	In molding by means of the floating punch, decrease floating of the part shaping the recess
Sticking on article surface	Poor quality of the working surfaces of punches: poor polishing, scratches	Polish punches, wipe them with alcohol or kerosene
Sticking of molding powder on mold punches	Carbon from the upper layer of punch made of instrumental steel burned out A crack lattice traced on hard-alloy punch	Implement flat grinding and finish of punches after hardening using a coolant
Nonuniform thickness	Nonuniform charging of molding powder in the mold Incorrect position of the mold	Control uniformity of molding powder charging Eliminate the mold skew
Deformation of article after molding (convex parts)	Absence of conicity in the matrix Heterogeneous moisture, heterogeneous material and granulometric composition of molding powder Inhomogeneity of molding powder in moisture, chemical and granulometric composition	Replace the matrix Check the flat alignment of the matrix Control charging of the powder Control moisture and granulometric composition of molding powder

TABLE 1 (*continuation*)

Types of defects	Possible causes	Measures for eliminating defect
Emergence of cracks in the recess base	Absence of conicity or a reverse cone on the rod shaping the recess in article	Make a cone on the rod in compliance with the mold blueprint
Deformation of articles during firing	Inadequate packing of articles sent to firing Excessive firing temperature	Comply with article packing technology and firing schedule
Dark spots on article surface (iron inclusions)	Deviations from powder-preparation technology Tarnish from refractories	Comply with technology of molding powder preparation (contamination of powder) and refractory-making technology
Pores and holes in articles	Molding powder contaminated with organic impurities	Strictly comply with powder preparation technology Reject molding powder
Electrocorudum (filler) fusing to article	Excessive firing temperature Electrocorundum not purified from iron impurities or fired at a low temperature	Comply with firing schedule Wash electrocorundum Fire electrocorundum at a temperature not lower than the temperature of firing product
Deformation of articles with a recess in firing (bulge on the reverse side of the recess)	Excessive compression on the site of recess	Use differential-pressure punches and increase floating of the recess-shaping part
Underfiring of lower rows of articles in the tunnel furnace	Lower tray is insufficiently heated	Adjust the thermal regime of the furnace
Microcrumbling on the molding part of punches	The punches were overhardened during their manufacture	Comply with hardening regime in making punches
Radial cracks around holes (in articles with a great number of holes)	Deflection of pin-marks shaping openings in articles due to non-coaxiality of punches and pusher Pin-marks shaping openings in articles are not rectilinear, have a sag Absence of conicity on the marks Poor finish of the surface of the marks	Improve the precision of coaxiality of the punch and the pusher in manufacture Manufacture mold parts (punch, pusher, mark-holder) as a set Introduce control of straightness of marks using a special instrument Introduce a cone on the marks, control the mark diameters, and improve their finish purity
Insufficient compression on automated presses of type 292	Incomplete filling of the matrix with molding powder (causes: a skewed bunker, which during its reverse motion picks some powder from the matrix, powder is blown out from the matrix by compressed air intended for air cooling of articles, due to excessive air pressure or untimely switching on, i.e., when the powder is not yet compressed)	Eliminate skewing of the bunker on the press machine Check the clearance between the bunker and the mold plate using a clearance gage Check the pressure of compressed air pressure for air cooling of articles (pressure should not be higher than 0.15 MPa) Adjust compressed air feed for air cooling Set air feed at the final compression stage when the article is partially compressed
Stratification of articles	Discontinuity on article surface in the form of notches or cracks arising under excessive molding pressure	Decrease molding pressure
Granularity in the lateral side of article	Molding powder contains coarse-fraction particles	Use molding powder or a finer fraction (average particle size of powder should be 4 – 5 times smaller than the minimum distance between the metal compressing parts of the mold)
Pores in articles	Air is pressed in	Remove air from molding powder in molding using any of the following methods*
Burn-out	Burning-out inclusions penetrate into molding powder	Prevent contamination of molding powder
Green and yellow spots	Tin mesh filaments or lubricants penetrate into molding powder	Keep tin sieves and equipment clean
Iron fusion	Metallic grating from the guiding columns of the press and from the bunker against the mold plate	Keep the press clean, protect guiding columns from penetration of molding powder

* Decrease the number of motions of the press spindle; modify the press cyclogram introducing stepwise feed of molding pressure and exposure at the final pressure (unit pressure at the first step should not exceed 0.1 – 0.2 MPa, the second step should be increased compared to the first step); deposit notches on the end and lateral; surfaces of the pusher with angle 30°, depth 0.2 – 0.3 mm, and spacing 1.0 – 1.5 mm.

that increasing the quantity decreases the friability, mobility, and air permeability of molding powder when molding pressure is developed.

Furthermore, an elevated quantity of the dustlike fraction increases the probability of arch formation inside the filled mold, which enhances the number of defects in the molded article [4].

Technological equipment is a very significant factor affecting the quality of ceramics produced. The most essential piece of equipment in molding is the mold.

The quality of a finished product to a large extent depends on the material and quality of the mold. Molds made of materials with low wear resistance soon become worn in service due to abrasion of ceramic powder, which results in deviations from prescribed article sizes and formation of flashes and burrs on the article. Local wear in the mold matrix causes formation of ring-shaped cracks due to shear stresses arising as the article is pushed out of the matrix.

The absence of conicity on a mold matrix leads to deformation of articles in firing. The cone should be applied not from the upper end of the article molded, but from its bottom end. Even in molding miniature articles of height from 1 to 4 mm, this sequence of introducing conicity is a most significant factor permitting one to avoid the polishing stage in mass production [4].

It is known that a polishing operation significantly increases the production cost of ceramics due to additional labor involved in polishing, consumption of grinding tools, machinery service cost, and also due to higher consumption of ceramic materials, considering tolerances needed for polishing articles.

Technologists should periodically carefully inspect molding equipment in service. Molds received from a manufacturer require especially thorough checking with respect to their geometrical sizes and materials used, as well as hardness and purity of working surfaces.

It should be added that lubricants have an important role in mold service, since they decrease mold wear. Lubricants are applied on the working part of the mold in a thin layer. In some cases lubricants are introduced in the molding powder composition, and an optimum content is selected. The polyvinyl-glycerin binder for molding powders used by us not only decreases external friction of powder against the mold walls, but also decreases inter-particle friction within powder, and, therefore, facilitates a decrease in molding pressure, the density gradient, and the force of pushing the article from the mold, as well as allows for conducting the molding process without lubricating molds.

Long-term practical experience in static molding of ceramics on automated press machines 292, 1512, 1513, KA8124, KB8124, and KA8130 made it possible to identify probable causes of defects and suggests measures for their elimination (Table 1).

Molding on automated presses requires careful implementation of the process, making it possible to narrow technological parameter limits. All types of defects arising in molding are virtually impossible to remedy at subsequent stages of the process. Consequently, high quality of the final product depends mainly on selecting the optimum molding regimes and complying with technological regulations.

REFERENCES

1. R. Ya. Popil'skii and V. F. Kondrashov, Molding Ceramic Powders [in Russian], Metallurgiya, Moscow (1968).
2. M. I. Timokhova, "Methods for determining technological properties of ceramic molding powders," *Élektronnaya Tekh., Ser. Materialy*, Issue 4, 121 – 128 (1978).
3. M. I. Timokhova, "Some types of defects in static molding of technical ceramics," *Steklo Keram.*, No. 12, 21 – 25 (2003).
4. M. I. Timokhova and L. I. Medvedeva, "A highly efficient process of molding miniature ceramics," *Steklo Keram.*, No. 8, 13 – 15 (2003).